Space Weather Technical Forecast

Issued on Wednesday, 25 January 2023 at 09:45 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: Reducing risk of R1/R2 Radio Blackouts. Slight chance of G1/Minor Geomagnetic Storms on Day 2 (26th).

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity has been Low over the past 24 hours with only C-class flares observed. The largest flare was a C9.4 flare from the vicinity of AR3192 at 24/1435 UTC. There are currently nine numbered sunspot regions and one unnumbered sunspot group on the visible disc. AR3190 (Eki/Beta-Delta) in the far southwest remains the largest group, with the greatest potential for significant flares. The group contains a moderately sized delta spot, attached to the large spot in the rearward portion of the group. However, decay of its leading spots has continued in recent hours. The region should reach the western limb at the end of the UTC day on Day 1 (25th).

AR3192 (Dai/Beta) in the far northwest remains in a state of flux, with numerous small spots, moving around the moderately sized spot in the north of the group. This group should reach the western limb around the middle of the UTC day on Day 2 (26th).

There has been some minor development in the lead spots of AR3197 (Ero/Beta-Gamma) in the northern hemisphere near centre disc. Further analysis suggests this region could in-fact be two separate groups at similar latitude in close proximity, containing two simple bipolar regions, rather than one, larger and more complex group as it is currently. This region was responsible for some ejecta, starting around 24/1240 UTC, although no clear evidence of a CME can be detected in either LASCO or STEREO-A imagery.

There are currently numerous filaments on the solar disc, with most of these concentrated near the western solar limb in both hemispheres, which is of note as they could be triggered by the more active sunspots here should they flare appropriately. This appears to have occurred with the LDE C-flare from AR3192 starting around 24/1400 UTC, which released a moderately-large filament and associated CME, but is not Earth-directed.

The Type-II radio emission with an associated estimated speed of 324km/s was reported at 24/0324UTC. The source may have been a minor C2.5 from AR3198, near centre-disc, although the nearest ejecta appears to be heading northeast from LASCO and STEREO C2 and is deemed to be far-sided with coincidental timing with the flare from AR3198. No clear Earth-directed CMEs have been observed, however, some faint ejecta, perhaps associated with occasional flare activity, cannot completely be discounted as having some Earth directed trajectory.

Solar Wind / Geomagnetic Activity: Solar winds, as measured at L1 by ACE and DSCOVR, have been at slightly elevated to elevated levels 450-500km/s, reducing down to background (around 390km/s) by the end of the UTC day on the 24th. The solar wind density was at mainly average levels, but has since reduced to below average since 24/0830 UTC, although this is coincident with a discontinuity between DSCOVR and ACE data. The IMF has been weak throughout, with a peak of 6.8nT at 24/1957 UTC. The north-south component of the magnetic field was weak and mainly positive. The phi angle was mainly positive (away from the sun)

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2023. All Rights Reserved.

during the period. Resultant Geomagnetic activity was Quiet (0-2 Kp).

Energetic Particles / Solar Radiation: The high energy proton flux (greater than 10 MeV) as measured at GOES16 has been at Background levels throughout.

High energy electron flux (greater than 2 MeV) has been at Normal Background to Moderate levels. The 24-hour integrated electron fluence stayed well below the Active threshold on a roughly level trend, with 1.06e7 integrated pfu observed at 24/2359 UTC.

Four-Day Space Weather Forecast Summary

Solar Activity: Solar activity is expected to be Low, with a daily chance of becoming Moderate, with the most potent regions in the far west of the visible disc. These should rotate off to become far-sided by the end of Day 2 (26th), reducing the daily chances of M-class activity, despite new regions likely rotating over the eastern limb in the coming days.

Solar Wind / Geomagnetic Activity: The geomagnetic forecast is of lower than average confidence for the period. The likelihood of any CMEs affecting Earth during the period is low.

Two HSS from coronal holes are anticipated to arrive at Earth on Day 2 (26th) and Day 3/4 (27/28th). The effects from both are expected to be relatively muted overall.

Geomagnetic activity is forecast to be Quiet through much of, if not all of Day 1 (25th), perhaps increasing to Unsettled late in the UTC day and likely Unsettled to Active by early Day 2, with a slight chance of G1/Minor Storm conditions. Thereafter, activity reducing to mainly Quiet to Unsettled, with a very slight chance of a G1/Minor Storm interval between Days 3 and 4.

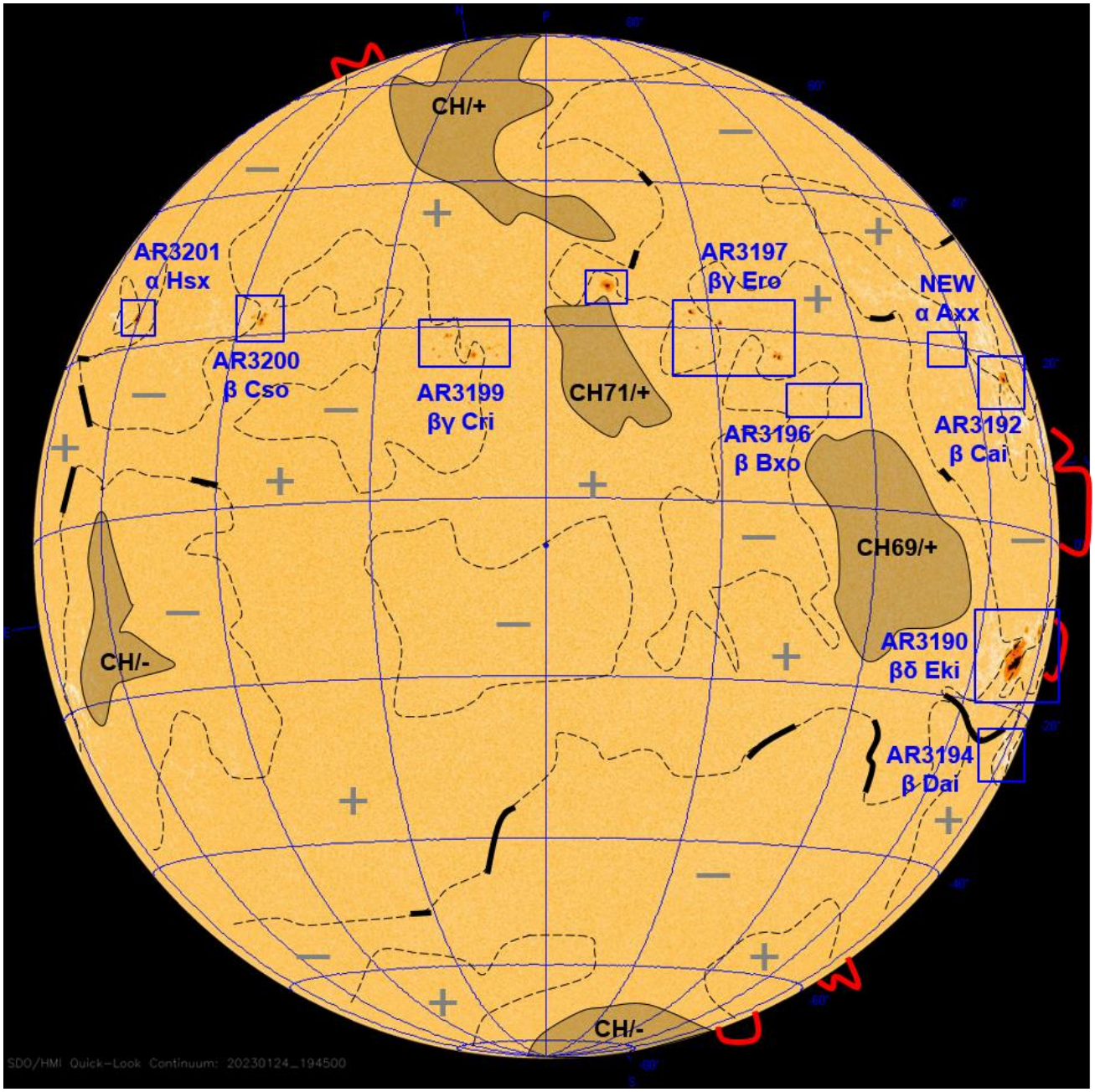
Energetic Particles / Solar Radiation: The high energy (greater than 10 MeV) proton flux observed by GOES16 is likely to remain at predominantly Background levels, but with a slight chance of reaching S1 or greater through the period. This risk should begin to lower from Day 3 (27th) onwards.

Electron flux should initially remain at Normal Background to Moderate levels, as at present. The greatest likelihood of surpassing Active fluence should arrive from Day 3 following from the arrival of a coronal hole fast wind, with the effect on electrons rated as an eventual slight chance of Active fluence at peak.

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2023. All Rights Reserved.

Figure 1. Solar Analysis Valid 24/1945 UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2023. All Rights Reserved.

Geomagnetic Storms:

The geomagnetic forecast is of lower than average confidence for the period. No Earth-directed CMEs are currently forecast. Although some faint ejecta, perhaps associated with occasional flare activity over the past couple of days, cannot completely be discounted as having some Earth directed trajectory. However, any potential impacts would be expected to be weak.

Earth is currently in a background solar wind regime, awaiting the arrival of the CIR and eventual HSS from CH69/+. This is a new feature on this rotation promoting some uncertainty with respect to timings and speeds encountered. At the time of writing STEREO-A does not appear to have encountered either, so any effects at Earth are more likely to happen on Day 2 (26th). CH71/+ in the northern hemisphere, near centre disc, follows between Days 3 and 4 (27th and 28th). This feature is smaller and retrogressed on the disc relative to last rotation, meaning weaker and later arrival respectively. The effects from the coronal holes are expected to be relatively muted in any case, with both being positive polarity on our approach to the negative-favouring spring equinox.

Geomagnetic activity is forecast to be Quiet through much of, if not all of Day 1 (25th), perhaps increasing to Unsettled late in the UTC day and likely Unsettled to Active by early Day 2, with a slight chance of G1/Minor Storm conditions. Thereafter, activity reducing to mainly Quiet to Unsettled, with a very slight chance of a G1/Minor Storm interval between Days 3 and 4.

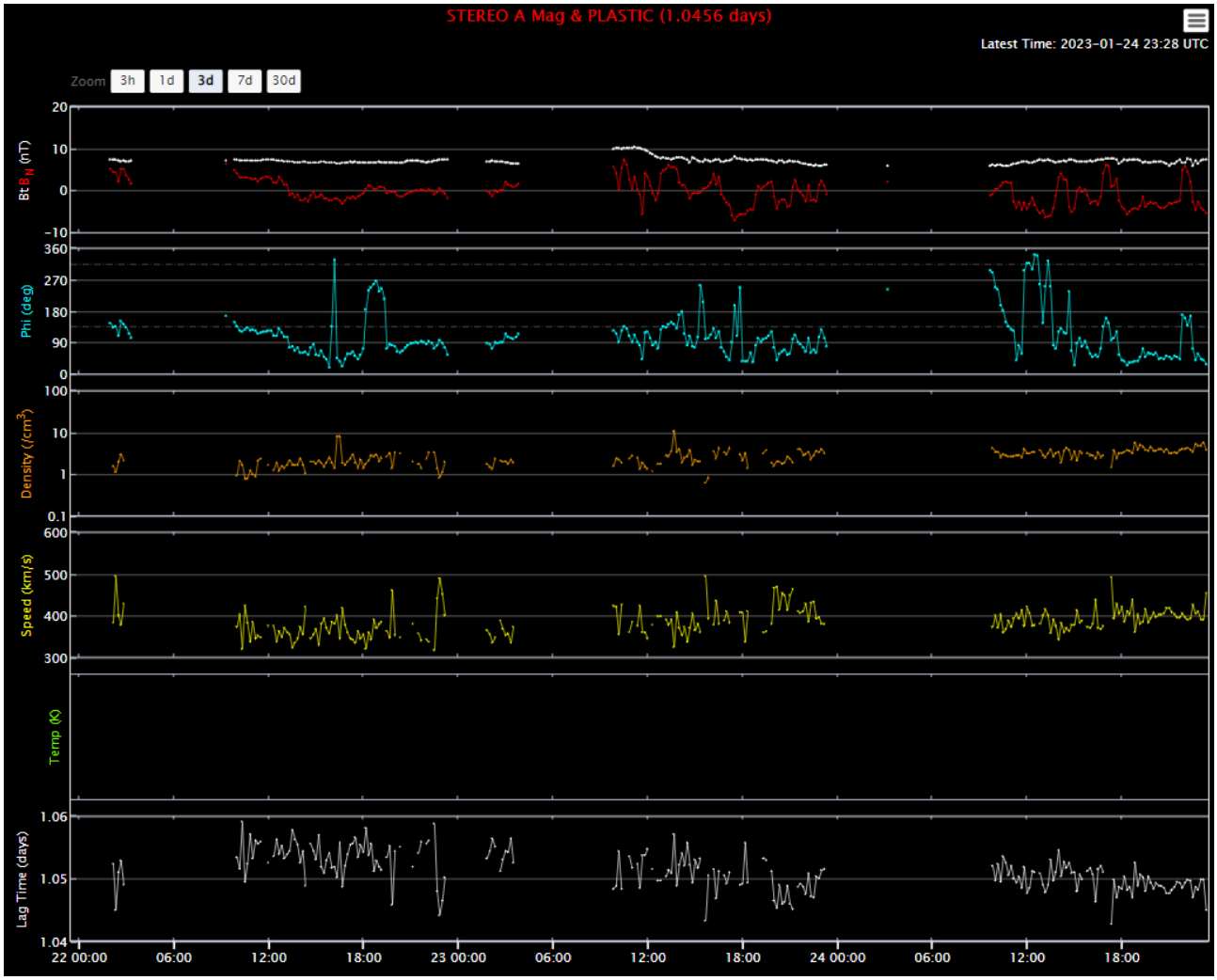
Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	No	5	20	10	10
Strong	G3	No	1	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections – Nil expected.

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2023. All Rights Reserved.

Figure 2: Past three days of STEREO A MAG and PLASTIC measurements. Despite a data gap suggests there is no significant fast wind within a day from influencing Earth.



Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2023. All Rights Reserved.

Radio Blackouts - X-Ray Flares:

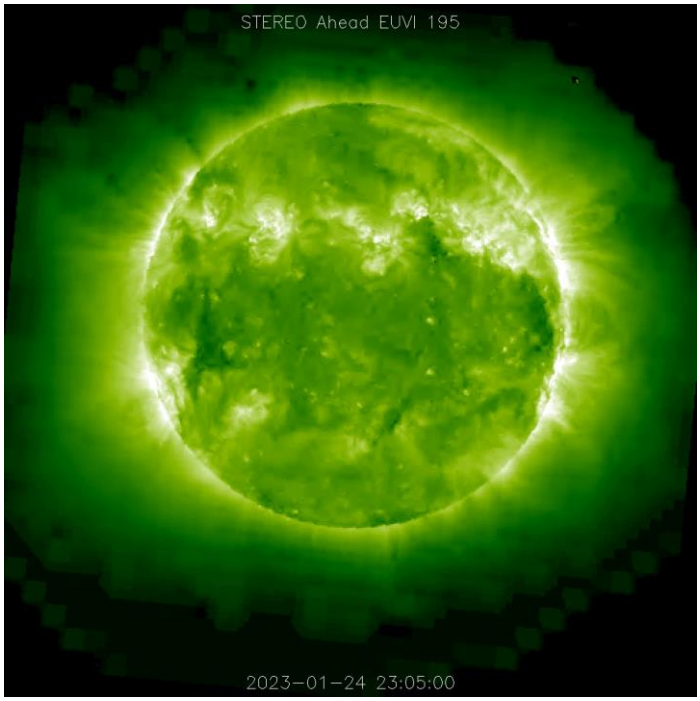
Solar activity has been Low during the past 24 hours.

While the disc remains well-populated in terms of sunspot region numbers, the relative complexity of the eastern solar hemisphere compared with the western limb is lower, and the departure of AR3190, AR3192 and AR3194 in the coming couple of days should serve to reduce the overall daily risk of M-class or higher flares.

Far-side soundings, returning Carrington locations of past spots and STEREO A EUVI195 imagery all hint that there may be a handful of arrivals over the eastern limb in the period, however aside from the far-sided halo CME from around 160E on the 23rd (its inferred emission position at that time), there is little evidence that any of these arriving sunspots will compensate for the departures, and the daily chances of significant flares therefore fall with time.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	No	50	40	30	30
Very Active	R3 to R5 X Class	No	5	3	1	1

Figure 3: 24/2305 UTC STEREO A EUVI195 imagery, indicating bright flux regions in the far east (left) that may contain sunspots around a day away from becoming visible at Earth.



Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2023. All Rights Reserved.

Solar Radiation Storms - (High Energy Protons):

The high energy (greater than 10MeV) proton flux is currently at Background levels.

While there have been examples of slight enhancements to around 1pfu in the past ten days or so at GOES16, the current disc does not appear to be particularly prone to their generation, and the largest sunspots on the disc have shown a tendency towards maturity and a general reduction in large flare activity.

All considered, there is a daily slight chance of S1 or above, with the chief contributors to this risk all now close to the western solar horizon. This risk should begin to lower as these regions rotate away onto the far side later this week.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	15	15	10	10
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

High Energy Electrons Event (≥ 2MeV):

Electron flux should initially remain at Normal Background to Moderate levels, as per its current diurnal oscillation.

The chances of geomagnetic activity before Day 3 (27th) are very low. The electron flux has not shown any willingness to rise beyond its current level even in this absence of geomagnetic activity, and the current observations probably represent a near-steady state.

Any electron response will probably arrive by the end of the current working week between the fast winds from CH69/+ and CH71/+, however this is now judged as a low-end chance, and even this ought to be brief should it occur.

MOSWOC REFM is not considered particularly useful guidance at present given the relative dominance of non-persistent features in the forecast, however it suggests levels below Active throughout the period.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	5	10	20	20
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2023. All Rights Reserved.

Figure 4: Latest GOES16 Electron Flux (above) and MOSWOC REFM model output (below). Notably recurrence forecasting is not recommended for indicating upcoming fluence levels. The forecast trend is more reliably below Active fluence throughout.

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2023. All Rights Reserved.